Active Galactic Nuclei: from Central Engine to Host Galaxy
ASP Conference Series, Vol. xxx, 2002
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The Orientation of Accretion Disks Relative to Dust Disks in Radio Galaxies

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Abstract. We study the orientation of accretion disks, traced by the position angle of the jet, relative to the dust disk major axis in a sample of 20 nearby Radio Galaxies. We find that the observed distribution of angles between the jet and dust disk major axis is consistent with jets homogeneously distributed over a polar cap of 77°.

1. Introduction

Studying the orientation of accretion disks relative to host galaxy disks can tell us about the inner structure of the galaxy and the regions around the black hole. It is reasonable to assume that gas from the galaxy disk is the source of fuel for the AGN, in which case we would expect the accretion disk to be aligned with the host galaxy disk, and the jets to be perpendicular to the host galaxy disk. The study of Seyfert galaxies (Kinney et al. 2000) shows that their jets can have any orientation, contradicting this scenario. In the case of Radio galaxies, which have elliptical or S0 host, it is difficult to determine the orientation the host galaxy disk. However, we solve this problem by using dust disks, a technique similar to that used by Kotanyi & Ekers (1979). We selected a sample of 20 Radio galaxies with dust disks and avoided sources with irregular dust lanes. These results are presented in Schmitt et al. (2002), and similar ones were found by Verdoes Kleijn et al. (this meeting).

2. Results

The main results of this work are presented in Figure 1. The left panel of this figure shows the distribution of angles δ, the angle between the jet and the dust disk major axis. It is clear that these radio galaxies present a wide range of values, between $\sim$ 15° and 90°. This suggests that the jets are not aligned perpendicular to the dust disks. However, the results from Figure 1 represent only a two-dimensional projection on the plane of the sky, and we are interested on the intrinsic, three-dimensional orientation of jets relative to the dust disks symmetry axis. Using the techniques developed by Kinney et al. (2000), we have that for a given pair of angles (i,δ), where i is the inclination of the dust disk relative to the line of sight, it can be shown that the jet will never be at an angle closer than $\beta_{min} = \sin^{-1}(\sin i \cos \delta)$ relative to the disk symmetry axis. The right panel of Figure 1 presents the cumulative distribution of β_{min}'s for our

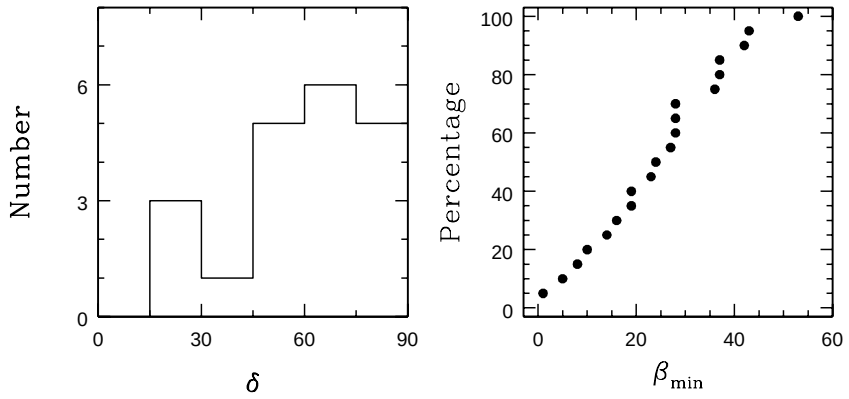

Figure 1. Left: The distribution of angles δ. Right: cumulative distribution of angles β_{min}.

sample, where we can see that it shows a large distribution of values, indicating that for half of the sample the jet and disk axis have to be misaligned by more than 20°, being larger than 53° for one of the galaxies.

Besides studying the distribution of angles β_{min}, we also used the statistical techniques developed by Kinney et al. (2000) to determine which distribution of angles β best represent the observed distribution of δ's. We find that a homogeneous distribution of jets over a polar cap of 77° can represent the data at the 5% level. However, jets seem to avoid lying along the dust disks, which may be due to the fact that they would not be able to propagate along that direction, or would possibly even destroy these disks.

Kinney et al. (2002) and Schmitt et al. (2002) discuss several possibilities to explain these results (see also Pringle, this meeting). Misaligned inflow of gas towards the nucleus, from minor mergers, or the accretion of individual molecular clouds do not seem to explain the observations, since they would resulting in misaligned jets from the VLBI to the VLA scales, which is not observed. Other possibilities would be the warping of the accretion disk by self-irradiation instability (Pringle 1996), by the Bardeen-Petterson effect, or by a misaligned gravitational potential around the nucleus. These explanations also present some problems and require further study.

Acknowledgments. I would like to thank my collaborators in this project: Jim Pringle, Cathie Clarke and Anne Kinney. The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

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